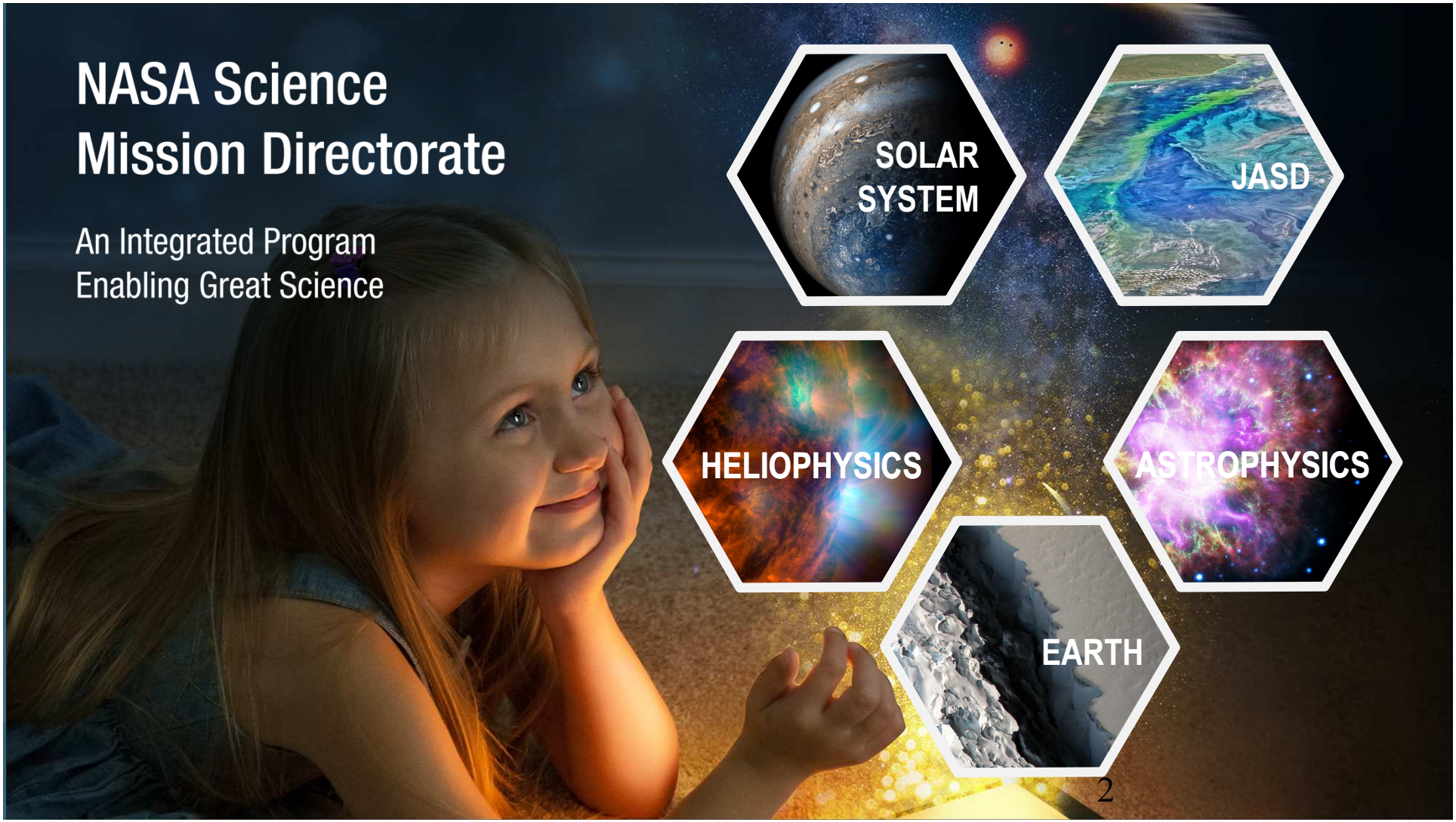
SPORT

Scintillation Prediction
Observations Research Task

SPORT: An international science mission using a CubeSat

Dr. James Spann, NASA Heliophysics Chief Scientist, SPORT PI
Dr. Charles Swenson, SPORT Deputy PI


NASA Science
Mission Directorate
An Integrated Program
Enabling Great Science
SOLAR SYSTEM
JASD
HELIOPHYSICS
ASTROPHYSICS
EARTH

Key Science THEMES

Protect & Improve Life on Earth

Discover Secrets of the Universe

Search for Life Elsewhere

Science by the NUMBERS

TECHNOLOGY INNOVATION

~$400M Invested Annually

RESEARCH

~10,000 U.S. Scientists Funded
~3,000 Competitively Selected Awards
~$600M Awarded Annually

SPACECRAFT

106 Missions
88 Spacecraft

CUBESATS

22 Science Missions
15 Technology Demos

SOUNDING ROCKETS

16 Science Missions
3 Tech/Student Missions

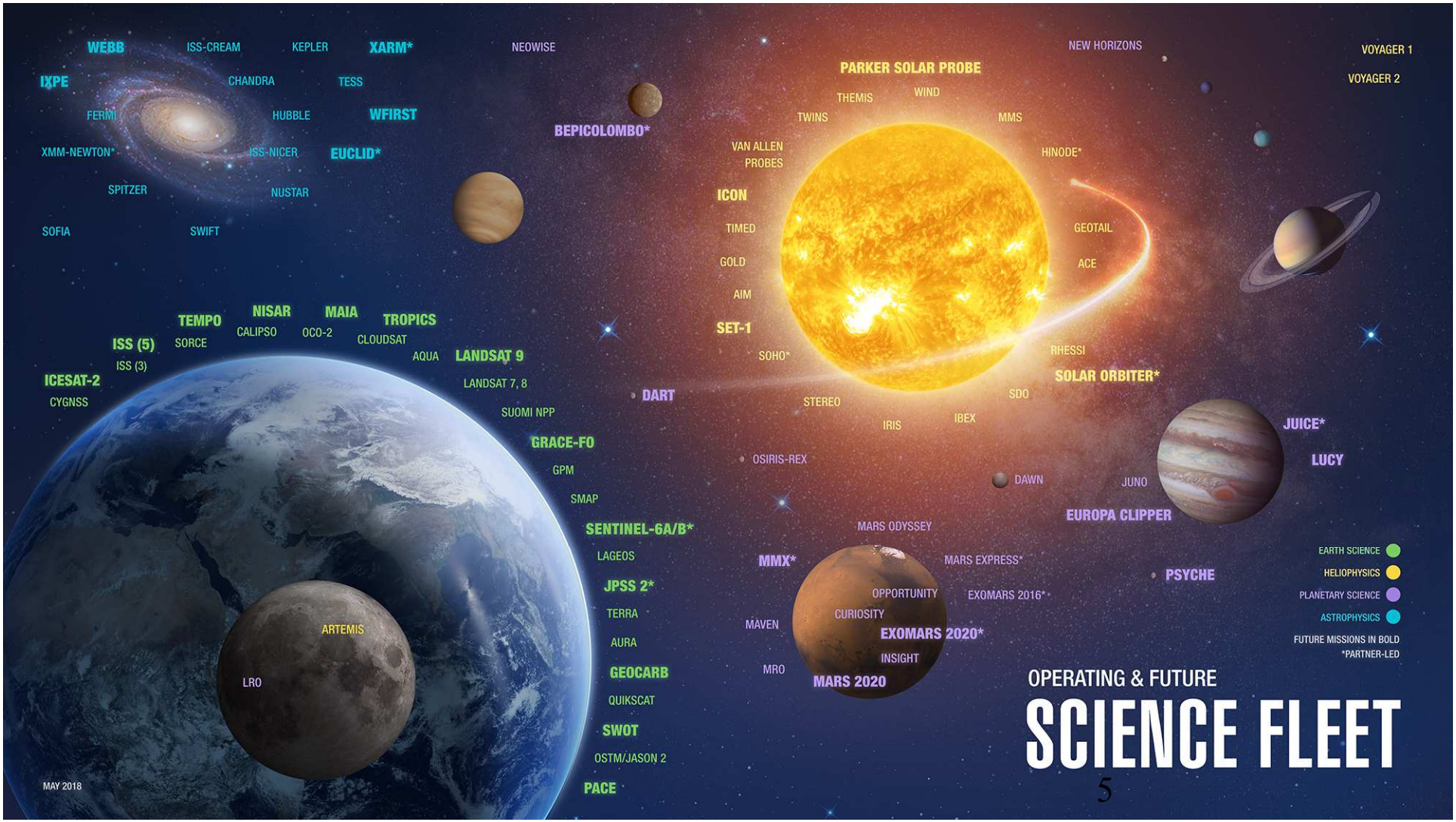
EARTH-BASED INVESTIGATIONS

25 Major Airborne Missions
8 Global Networks

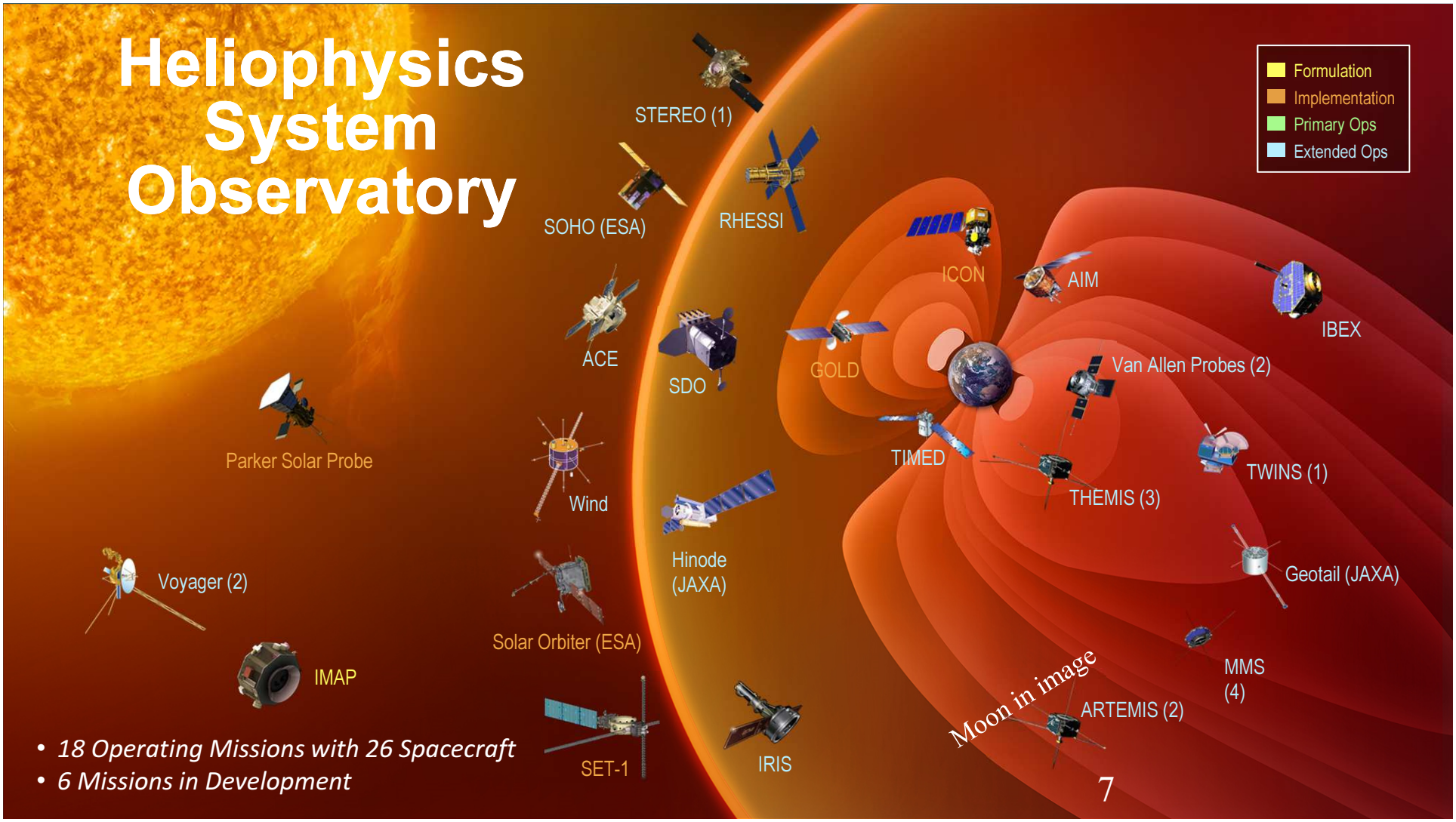
BALLOONS

13 Science Payloads
1 HASP with up to
12 student experiments

Current as of May 1, 2018


WEBB
ISS-CREAM
KEPLER
XARM*
NEOWISE
IXPE
CHANDRA
TESS
FERMI
HUBBLE
WFIRST
XMM-NEWTON*
ISS-NICER
EUCLID*
SPITZER
NUSTAR
SOFIA
SWIFT
BEPICOLOMBO*
PARKER SOLAR PROBE
NEW HORIZONS
VOYAGER 1
VOYAGER 2
THEMIS
WIND
TWINS
MMS
VAN ALLEN PROBES
HINODE*
ICON
TIMED
GEOTAIL
GOLD
ACE
AIM
SET-1
SOHO*
RHESSI
SOLAR ORBITER*
SDO
STEREO
IRIS
IBEX
TEMPO
NISAR
MAIA
TROPICS
ISS (5)
SORCE
CALIPSO
OCO-2
CLOUDSAT
ISS (3)
AQUA
LANDSAT 9
ICESAT-2
LANDSAT 7, 8
CYGNSS
SUOMI NPP
DART
JUICE*
LUCY
GRACE-FO
OSIRIS-REX
GPM
DAWN
JUNO
SMAP
EUROPA CLIPPER
SENTINEL-6A/B*
MARS ODYSSEY
LAGEOS
MMX*
MARS EXPRESS*
PSYCHE
JPSS 2*
OPPORTUNITY
EXOMARS 2016*
TERRA
CURIOSITY
MAVEN
EXOMARS 2020*
AURA
INSIGHT
GEOCARB
MRO
MARS 2020
QUIKSCAT
SWOT
OSTM/JASON 2
PACE
ARTEMIS
LRO
MAY 2018
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
FUTURE MISSIONS IN BOLD
*PARTNER-LED
OPERATING & FUTURE
SCIENCE FLEET

Heliophysics Science


Heliophysics System Observatory
Formulation
Implementation
Primary Ops
Extended Ops
STEREO (1)
SOHO (ESA)
RHESSI
ICON
AIM
IBEX
ACE
SDO
GOLD
Van Allen Probes (2)
Parker Solar Probe
TIMED
TWINS (1)
Wind
THEMIS (3)
Hinode (JAXA)
Voyager (2)
Geotail (JAXA)
Solar Orbiter (ESA)
MMS (4)
IMAP
Moon in image
ARTEMIS (2)
SET-1
IRIS
• 18 Operating Missions with 26 Spacecraft
• 6 Missions in Development
7

2018 Helio Highlights – Launches

Left: GOLD launches from French Guiana on Jan 25
Middle: Parker launches from Kennedy Space Center on August 12
Right: ICON to launch on a Pegasus from Kennedy Space Center, NET October 6

International Partners

ESA (Europe):

- Solar Orbiter

KASI (Korea):

- Development towards prototype coronagraph for balloon flight in 2019

ISRO (India):

- Three sub-working groups established
  - Aditya-1 mission collaboration, space weather modeling, long-term strategic collaboration focus areas

JAXA (Japan):

- Working with JAXA on approach for Next Generation Solar Physics Mission (NGSPM)

AEB (Brazil):

- SPORT CubeSat Mission, LRD 2020

Presentation Outline

- **Overview: SPORT science and mission**
- **A Story: how did it come to be**
- **The Status: where are we now**
- **Future Plans: where are we going**
- **Q/A**

SPORT

- **United States / Brazil Science Mission**
- **United States**
  - Science Instruments
  - Launch
- **Brazil**
  - Spacecraft
  - Operations
- **Joint**
  - Science Data Analysis

Instituto Nacional de Pesquisas Espaciais

Instituto Tecnológico de Aeronáutica

US Southern Command

The Aerospace Corporation

University of Texas Dallas

University of Alabama Huntsville

Utah State University

11

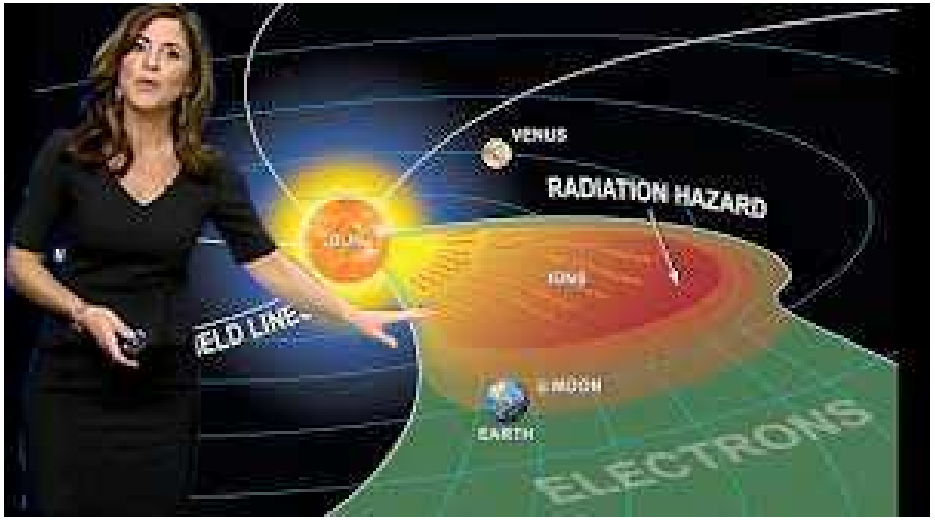
Funding and Resources

- **NASA HQ**
  - Heliophysics Technology and Instrument Development for Science
    - Low-Cost Access to Space, CubeSat program element
- **São Paulo Research Foundation – FAPESP**
  - Innovative Research in Research Institutes
- **USA DOD**
  - Coalition Warfare Program (CWP)

Forecasting the Weather

Earth Tropospheric Weather

Space Weather



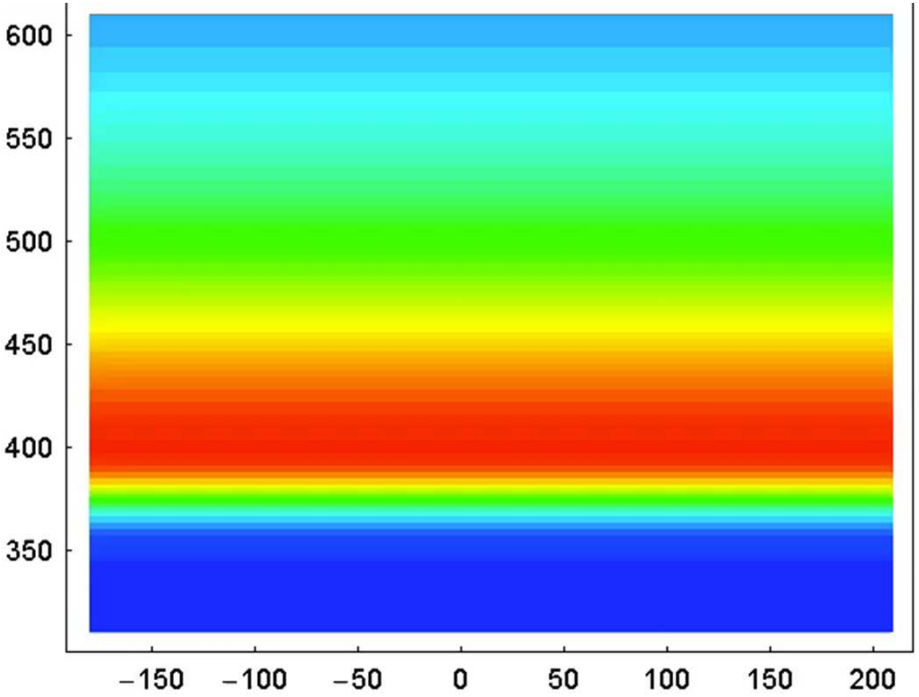
Science Goals

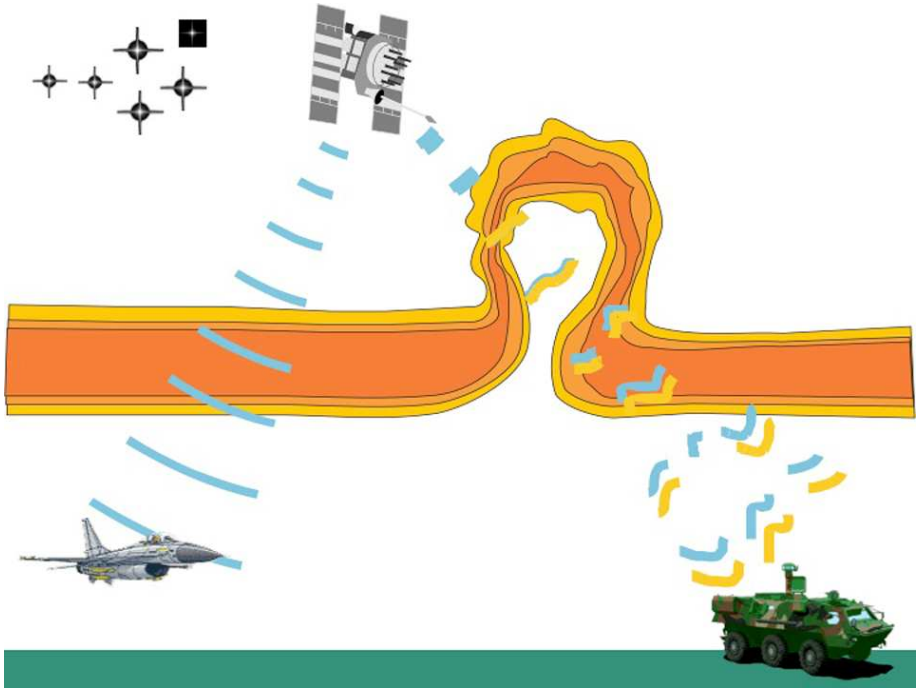
A science mission to understand the preconditions leading to <u>equatorial plasma bubbles and scintillation</u>

1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at <u>different longitudes</u>?

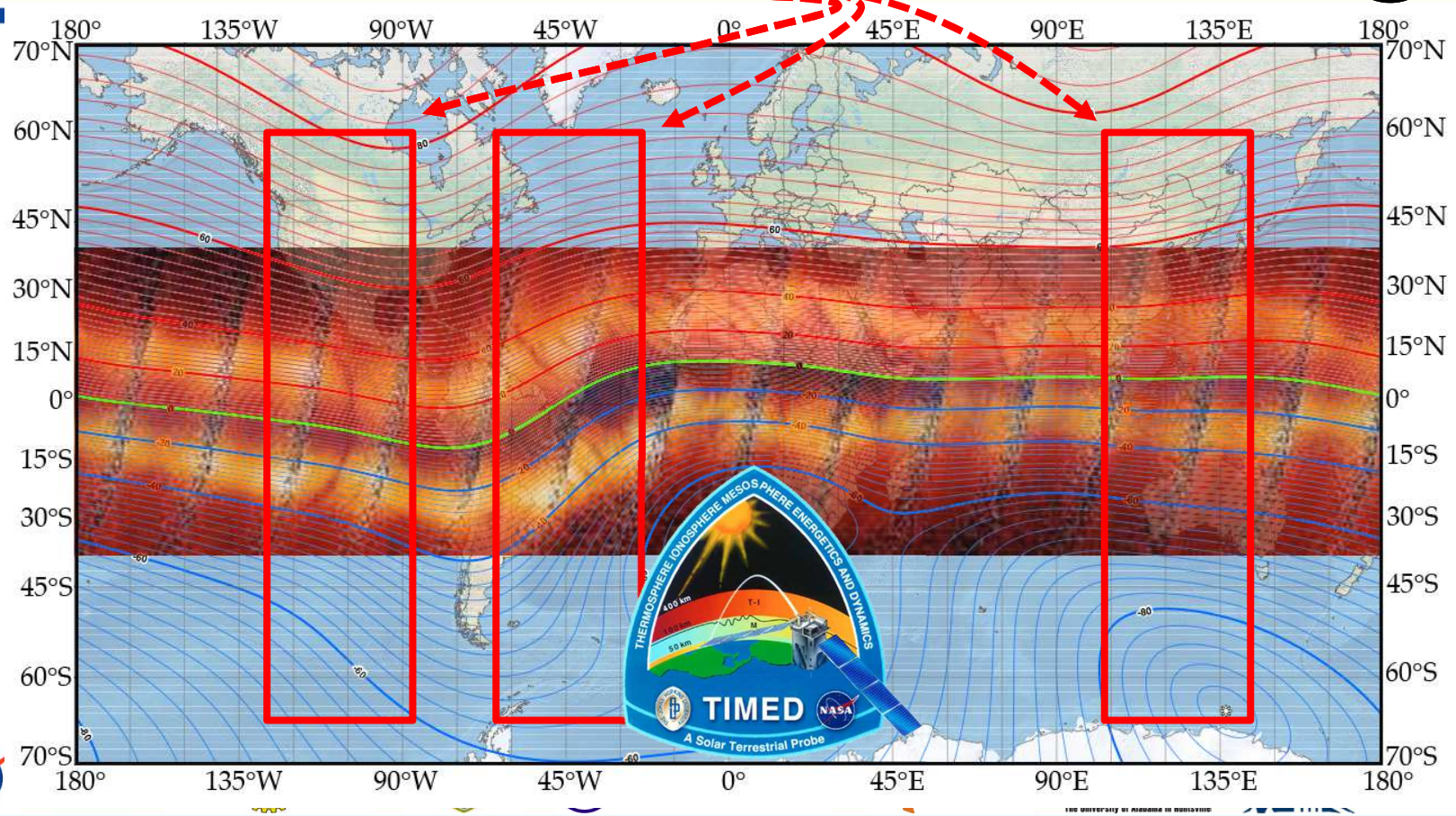
2) How are plasma irregularities at <u>satellite altitudes</u> related to the radio scintillations observed passing through these regions?

Ionospheric Plasma Bubbles





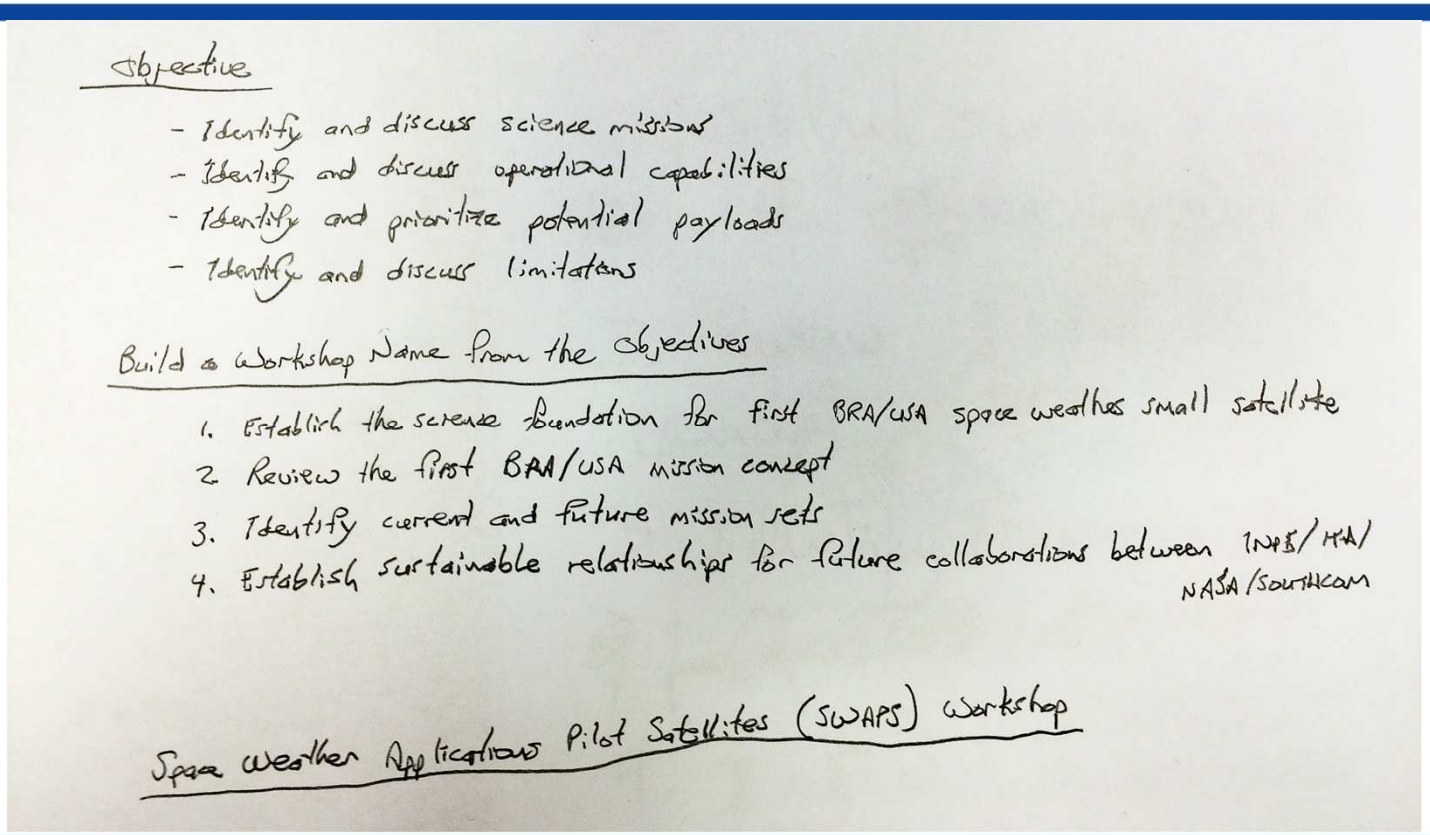
Why are these longitude regions different



SPORT
Scintillation Prediction Observations Research Task

November 2014

November 2014



Objective

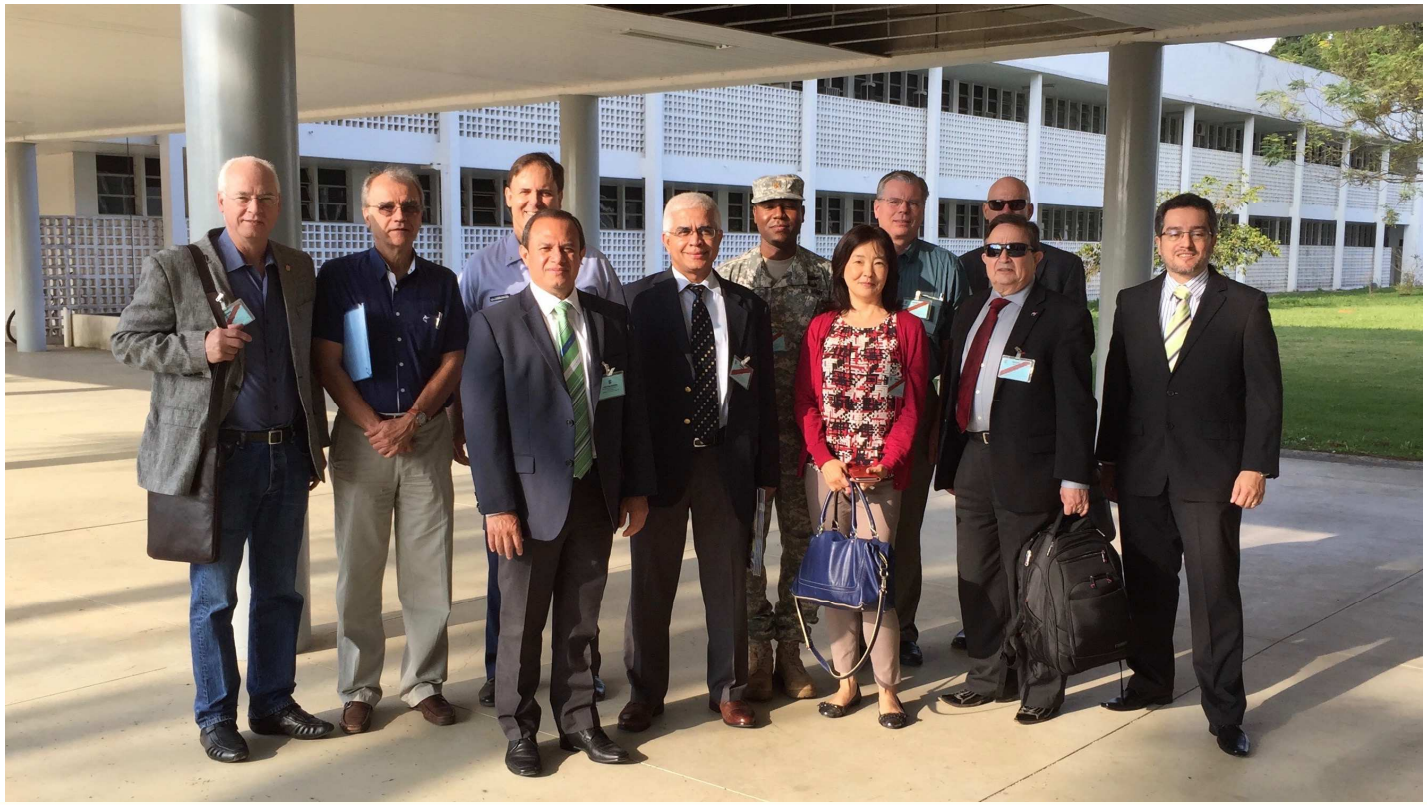
- Identify and discuss science mission
- Identify and discuss operational capabilities
- Identify and prioritize potential payloads
- Identify and discuss limitations

Build a Workshop Name from the objectives

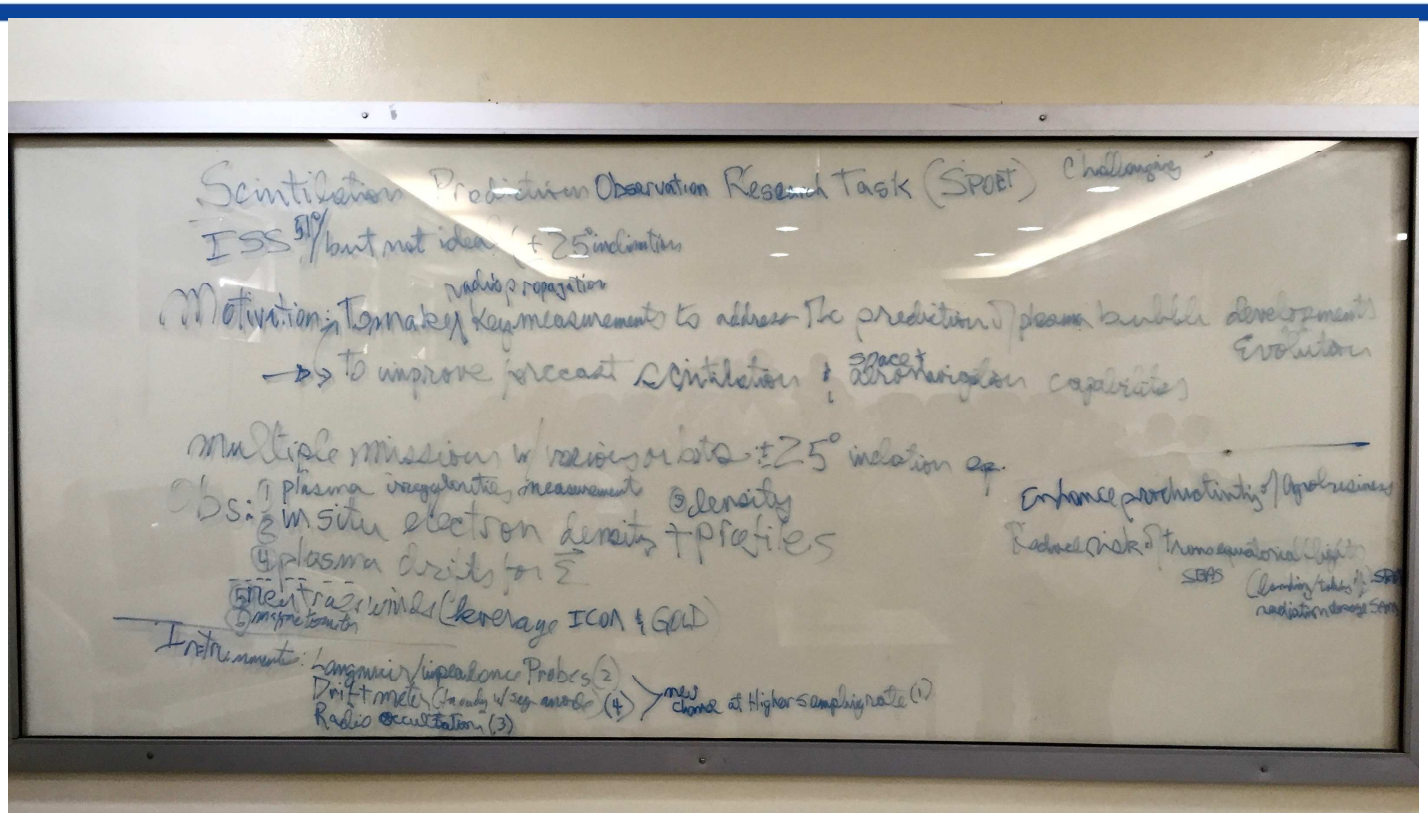
1. Establish the science foundation for first BRA/USA space weather small satellite
2. Review the first BRA/USA mission concept
3. Identify current and future mission sets
4. Establish sustainable relationships for future collaborations between INPE/MCTI/NASA/SOUTHCOM

Space Weather Applications Pilot Satellites (SWAPS) Workshop

May 2015

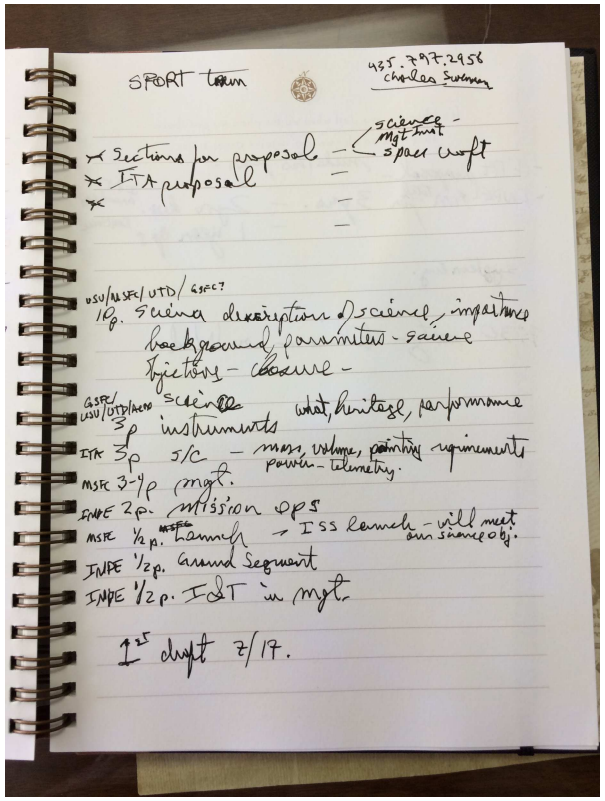


May 2015


Scintillation Prediction Observation Research Task (SPORT)
ISS
Motivation:
Key measurements
to improve forecast
Multiple mission
Instruments:
Langmuir/Impedance Probes (2)
Drift meter
Radio occultation (3)
(4)
Enhance
Evolution

July 2015

- **NASA HQ yearly solicits Principal Investigator lead science proposals**
- **Due to NASA HQ on 8/28/2015**
- **One month to prepare proposal!!!**
- **Not good**



August 2015

- **10/1/2018**

Convened team in Utah early August to work out technical details with ITA at The Utah State University Small Sat Conference

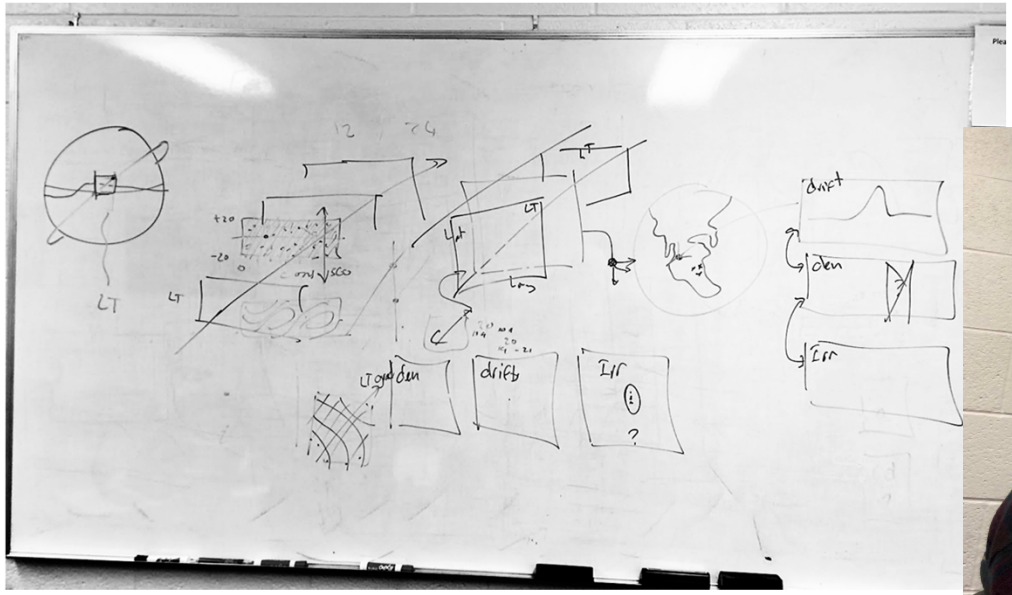
SPORT 2015 proposal

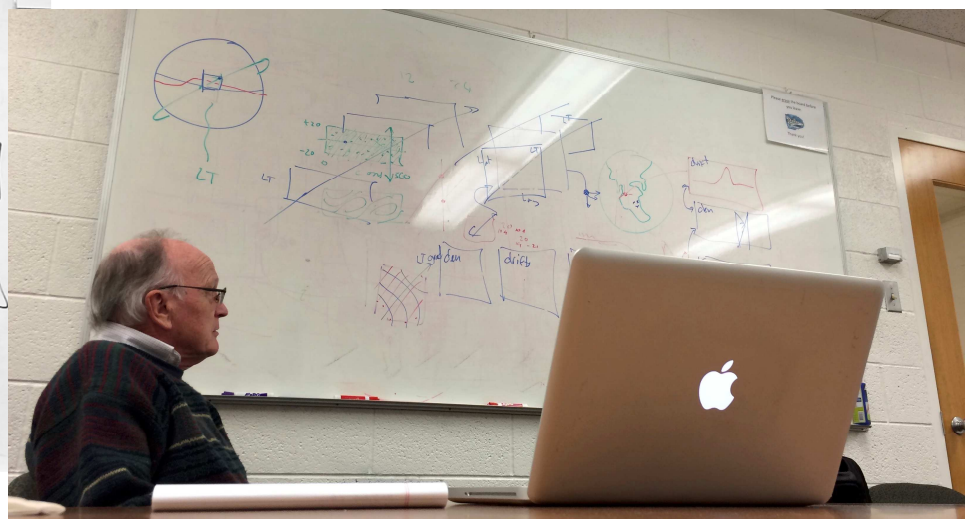
- **What is the state of the ionosphere that gives rise to the growth of plasma irregularities that extend into and above the F-peak?**
- **How do plasma irregularities evolve to impact the appearance of radio scintillation at different frequencies?**

- **Not selected – January 2016**
- **Review Feedback: Science overpromised for a single CubeSat**
- **HQ Feedback: Encouraged to resubmit**

March 2016

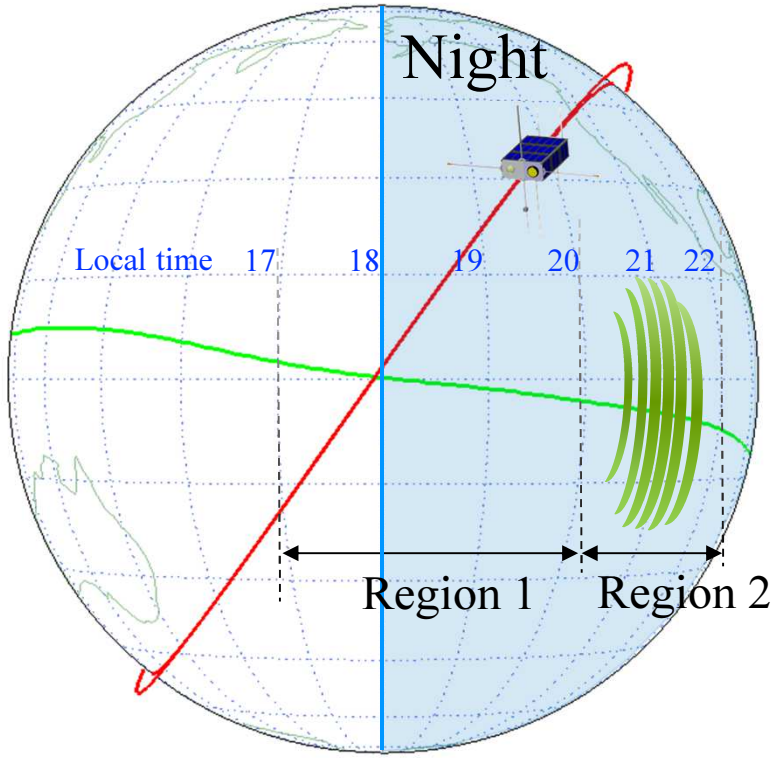
- **Back in Logan, Utah to sort out the science**



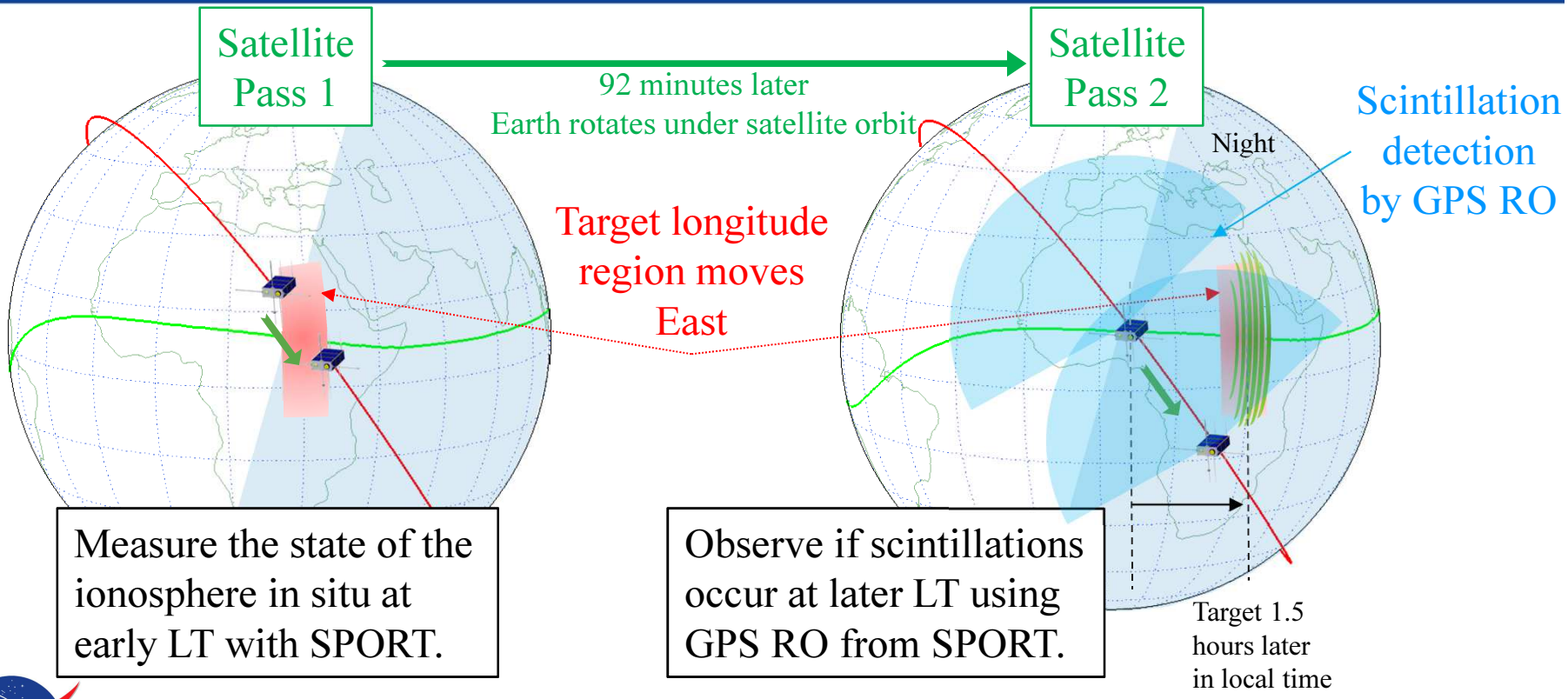


SPORT Methodology

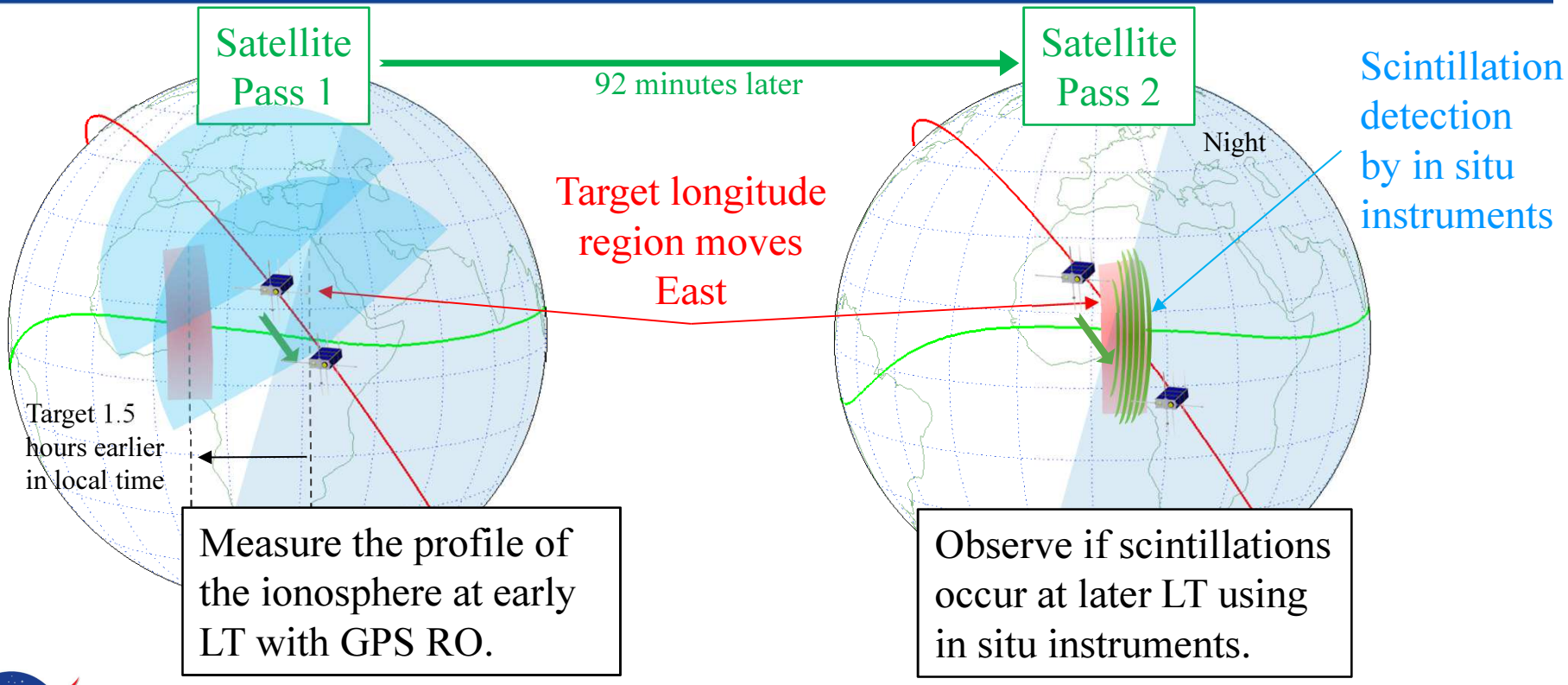
- **The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.**
  - How does this relation vary with longitude?
- **Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.**
- **Examine ~15 degree longitude sectors**



Methodology Strategy 1

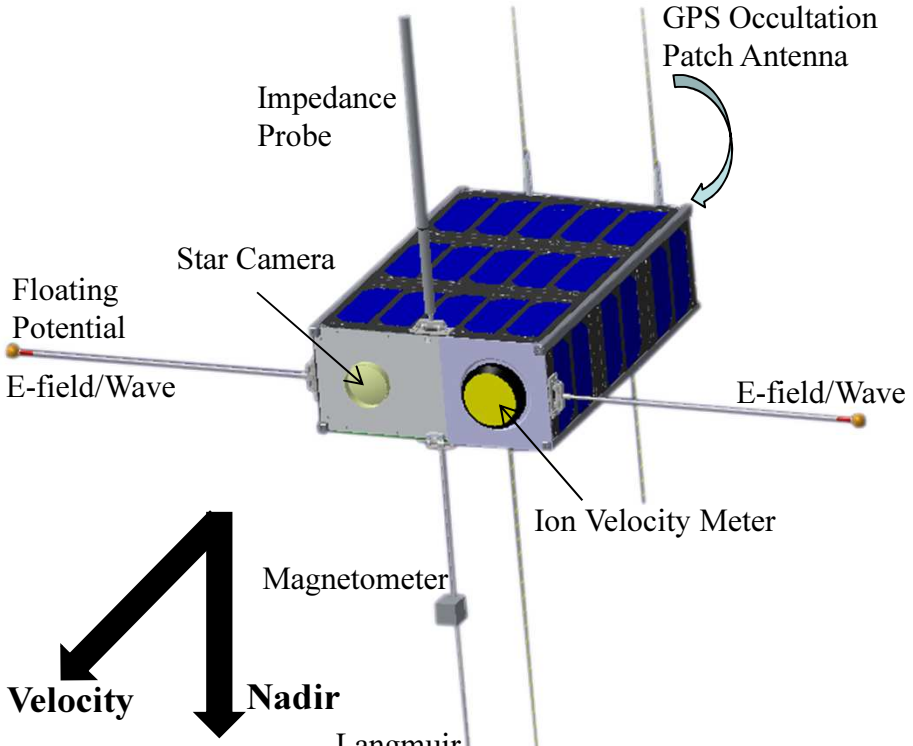


Methodology Strategy 2



Measurement and Instrumentation

Measurement	Instruments
Plasma motion	RPA/Drift meter
Plasma density / density profiles	GPS Occultation
Small scale structures and waves	Langmuir
Scintillation Index	Impedance
Magnetic field structure	E-Field
Plasma temperature	Magnetometer



SPORT 2016 Proposal

1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak <u>at different longitudes?</u>

2) How are plasma irregularities at satellite altitudes related to the radio scintillations observed passing through these regions?

- Pathfinder Mission for future more robust multi-satellite mission

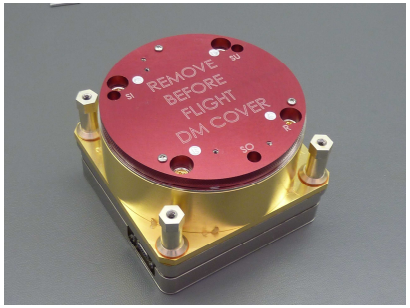
- **Submitted July 2016, Selected December 2016**

Now: International Agreements

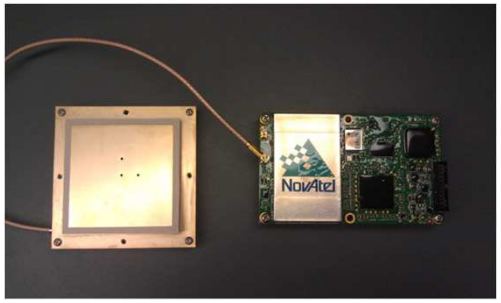
- The required U.S.-Brazil Framework Agreement was ratified in April 2018
- NASA transmitted a draft SPORT Implementing Arrangement to AEB in June 2018
- AEB is currently conducting the required Brazil-side reviews of the draft
- NASA OIIR is working with the U.S. Embassy in Brazil to press for expedient conclusion of the Implementing Arrangement

SPORT Instruments

Ion Velocity Meter
UTD

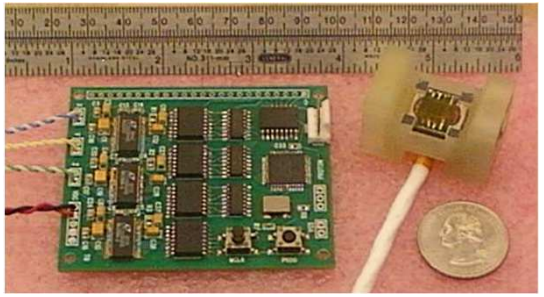


GPS Occultation
Receiver
Aerospace

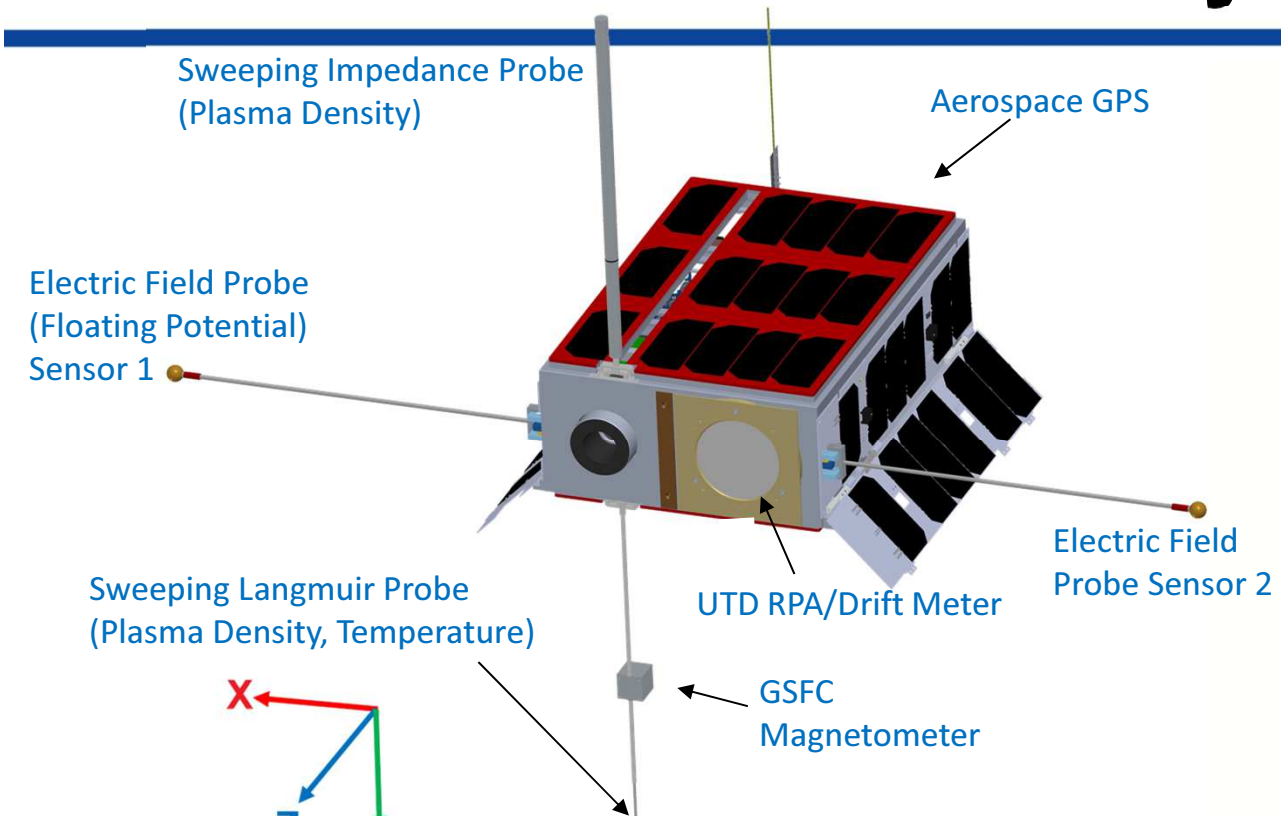


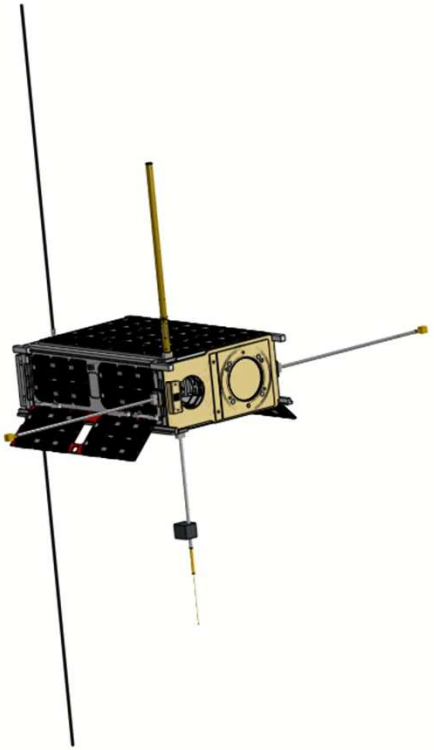
Langmuir, E-field,
Impedance Probe
USU

Fluxgate Magnetometer
NASA Goddard

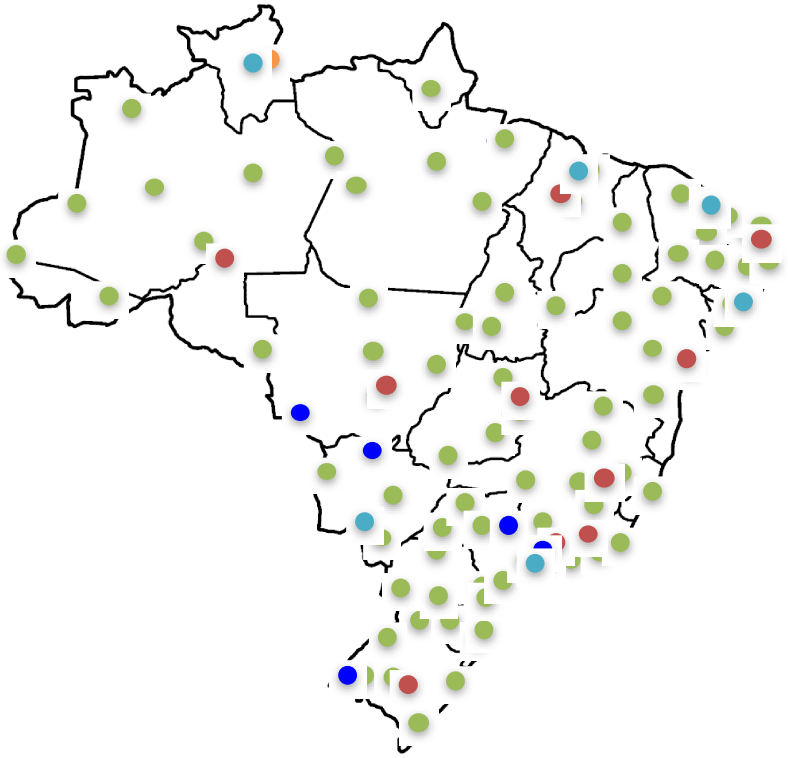


SPORT Observatory





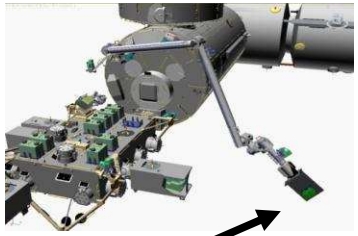
Ground Network

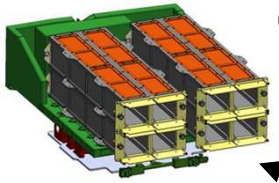


Ground Network

- Magnetometers
- Scintillation sensors
- TEC stations
- Imagers
- Ionosondes

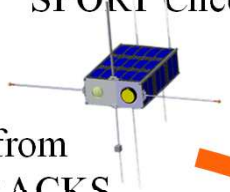
Mission ConOps





Installation

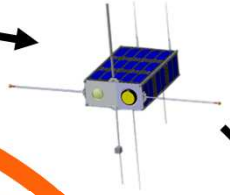
SPORT Checkout



Deploy from
NANORACKS
400 km alt

SPORT Operations

On-orbit Operations
(> 12 months)



Disposal
300 km alt

Soft
Package

Launch

Images: Charlie Gray

Design Review

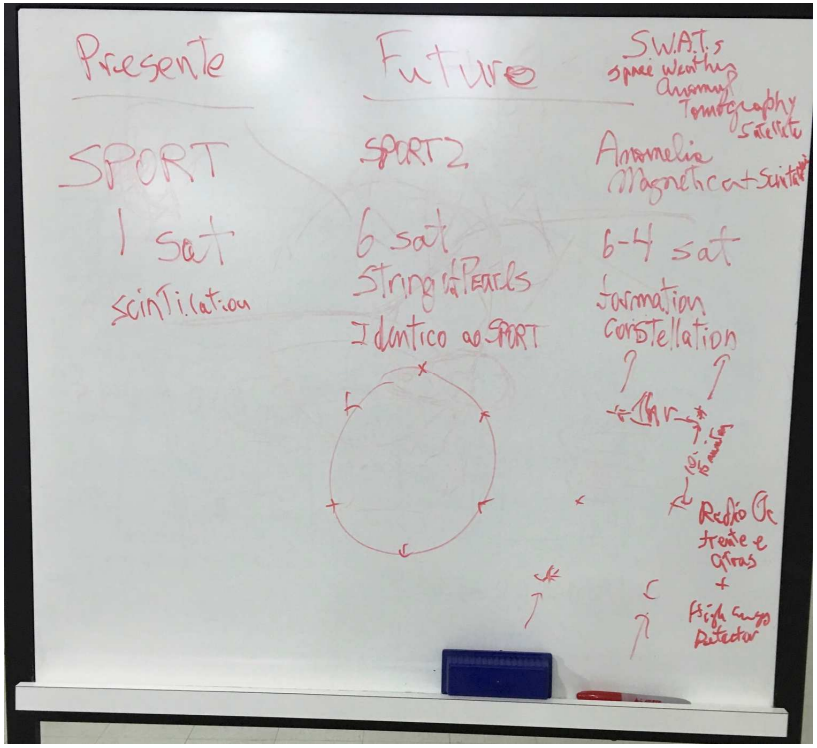
- **Succcessful Design review held at Utah State, Logan Utah, in August, 2018**

now

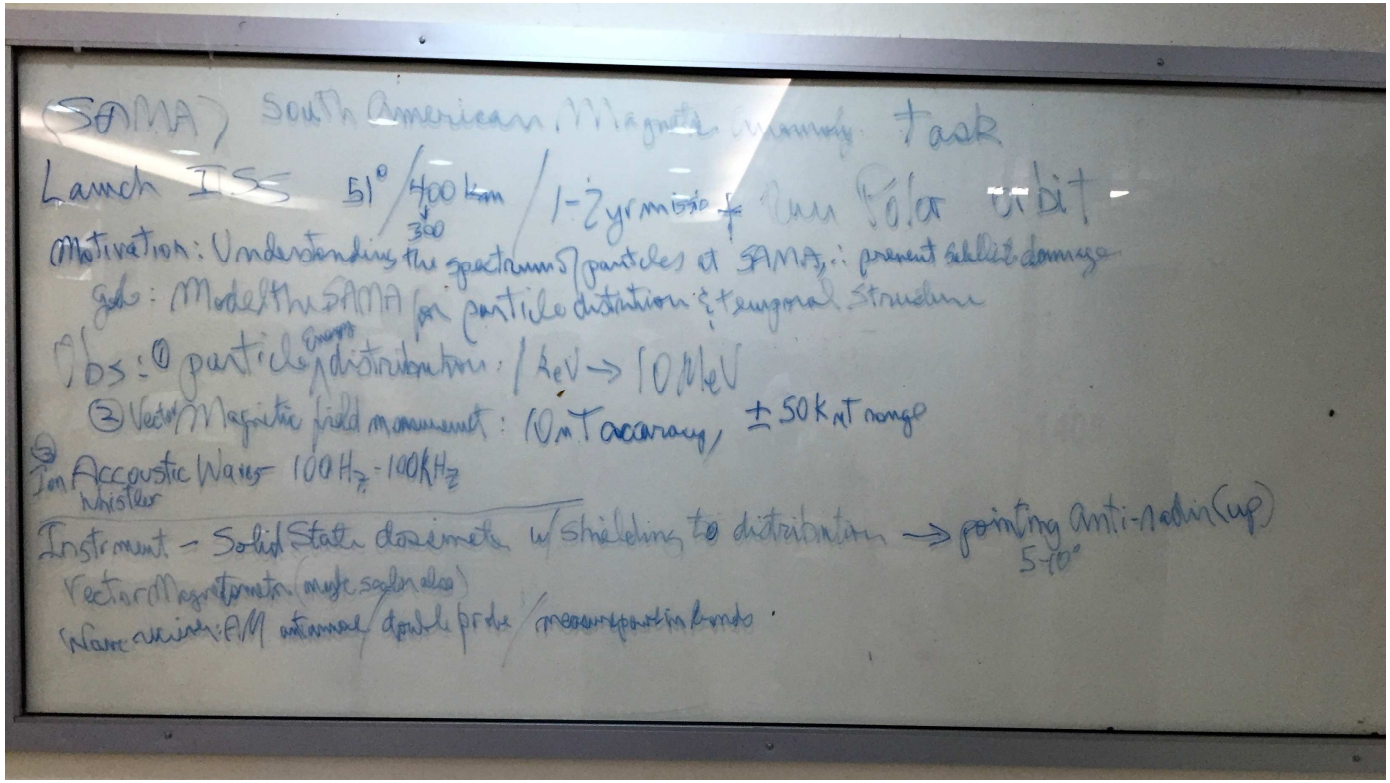
- Working with the Brazilian Space Agency, State Department, and OIIR at NASA HQ to establish the mechanism for collaboration – NASA/AEB Framework Agreement signed March 28, 2018
- ITAR and EAR issues are being addressed
- Funding of US instrument providers: USU, UTD, Aerospace, GSFC, and role of UAH in SE
- Establishing academic partnerships with INPE and ITA with US and UAH
- Working frequency allocation for satellite communications
- Increased active role for DoD participation
- Spacecraft CDR planned for January 2019 in São José dos Campos

Future Plans

SPORT follow on mission



May 2015



Or another mission with greater GSFC engagement

Value of Science

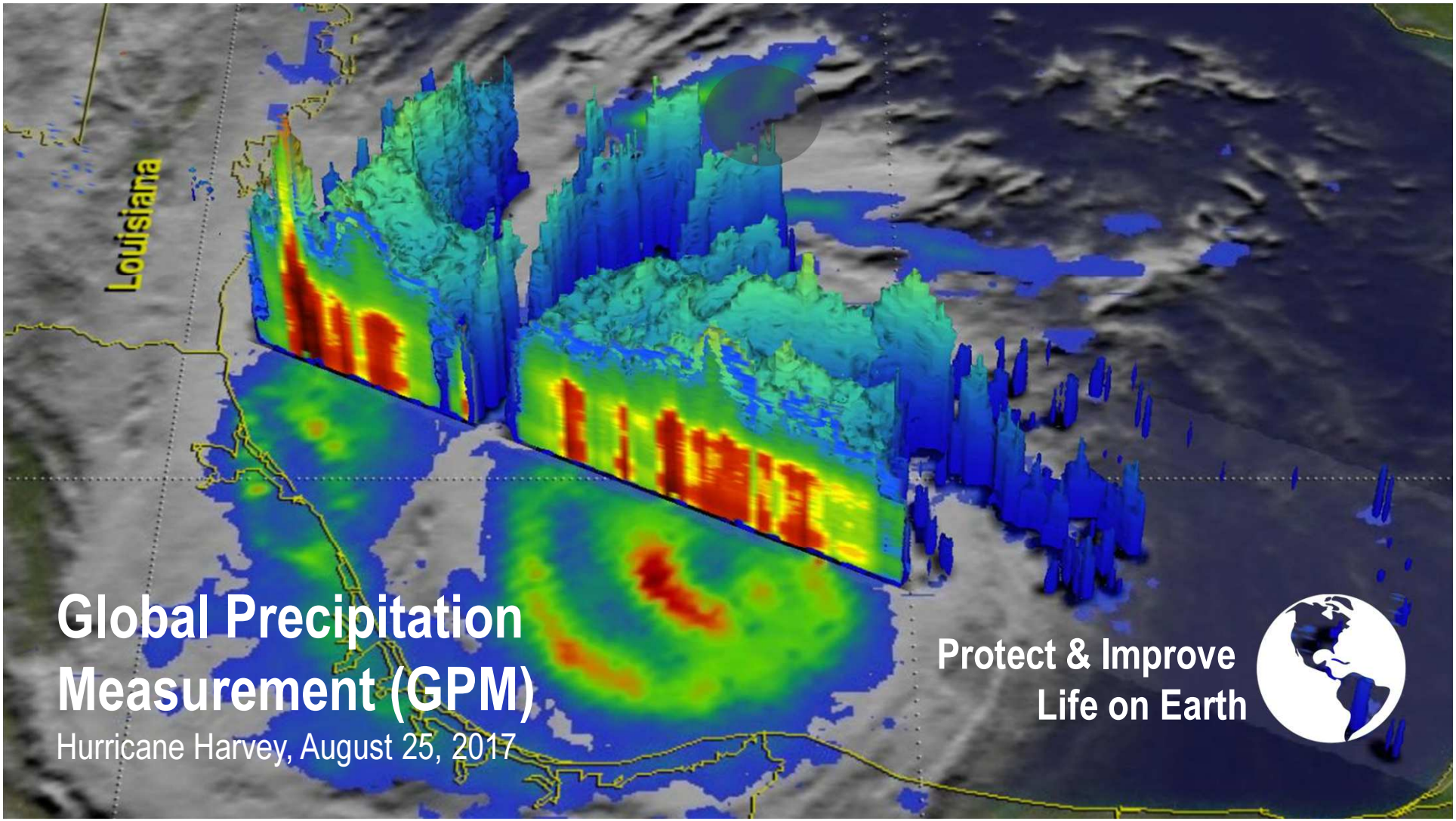
Take Aways

- **Advanced strategic planning is a requirement**
  - Science wins the proposal, but everything else can lose it
  - Better to be lucky than good, *but you have to be good*
  - Science is a team sport
  - Be persistent and diligent, nothing worthwhile is easy, pay attention to details
  - Science with an applied characteristic is more valuable – don't be a Homer

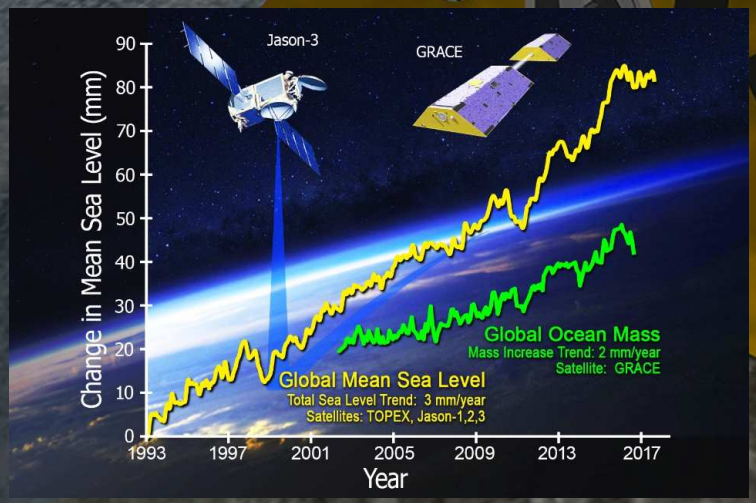
SPORT

Scintillation Prediction
Observations Research Task

BACKUP


Louisiana
Global Precipitation Measurement (GPM)
Hurricane Harvey, August 25, 2017
Protect & Improve Life on Earth

GRACE Follow-On



Protect & Improve Life on Earth

InSight

Discover the
Secrets
of the Universe

May 5, 2018 - NASA's InSight to Mars lifts off at Vandenberg Air Force Base in Central California

Discover the
Secrets
of the Universe

March 29, 2018 - Second stage of a United Launch Alliance Delta IV Heavy is mated to the common booster core at Cape Canaveral Air Force Station

PARKER SOLAR PROBE

A Mission to Touch the Sun

TESS

Launched April 18, 2018

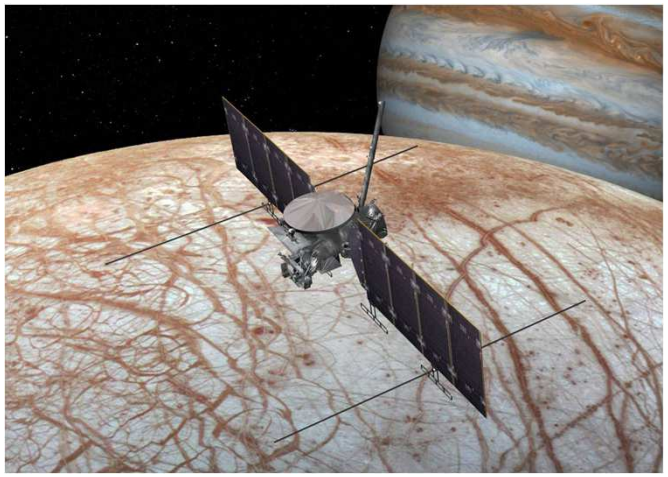
April 18, 2018 - SpaceX Falcon 9 rocket launches from Cape Canaveral carrying NASA's Transiting Exoplanet Survey Satellite (TESS)

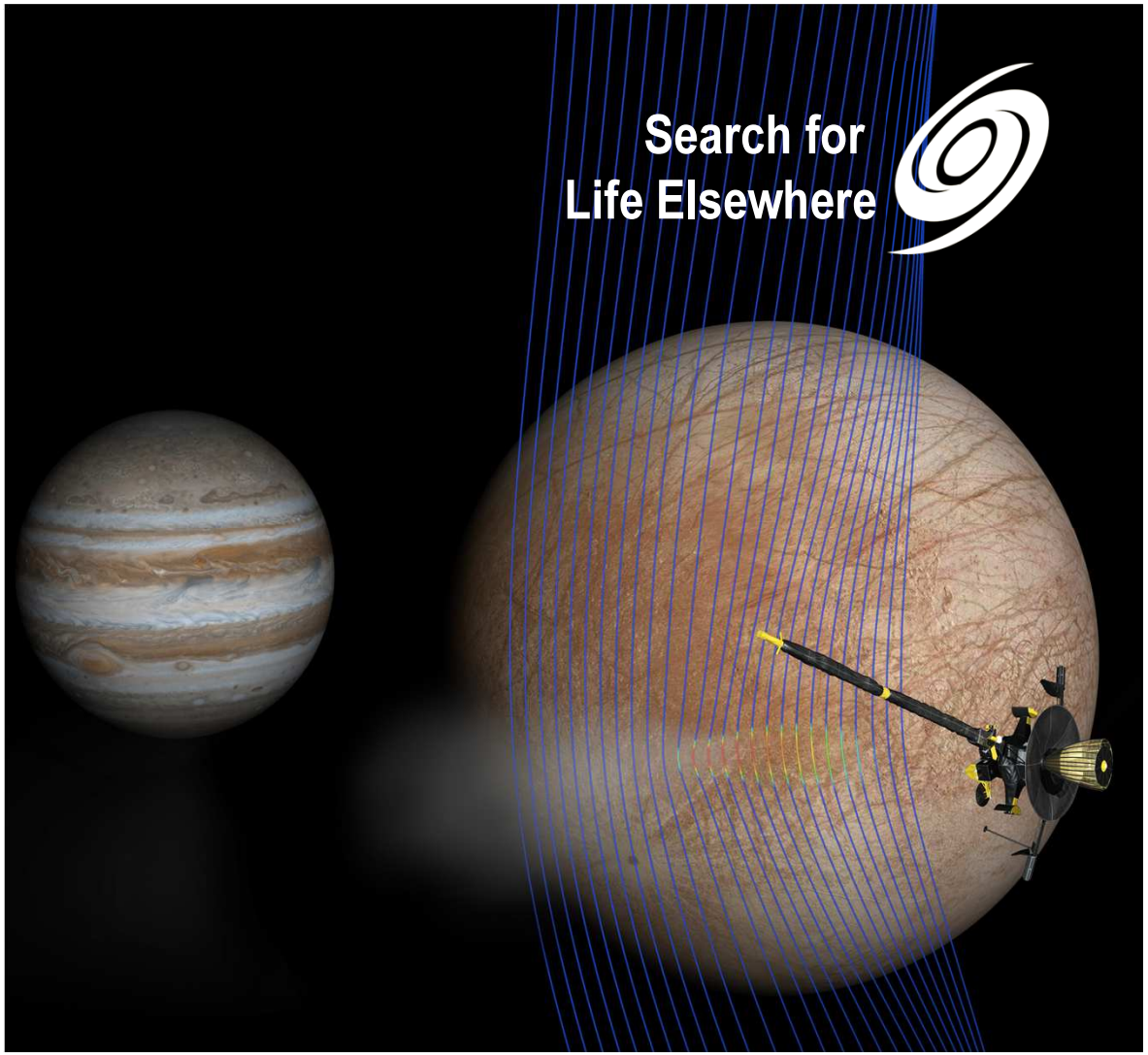
Search for Life Elsewhere

Search for
Life Elsewhere

Mars 2020

Mar 13, 2018 - A technician works on the descent stage for NASA's Mars 2020 mission inside JPL's Spacecraft Assembly Facility




Search for
Life Elsewhere

Value of Science